PLANTING NATIVE VEGETATION ON LANDFILL CAPS AND FORMERLY CONTAMINATED WASTE SITES IN THE MID ATLANTIC

INTRODUCTION

In the past, most landfill caps and remediated waste sites have been vegetated with a monoculture of cool season non-native turf grasses (e.g., Tall Fescue or Kentucky 31). These non-native species may provide quick cover that can stabilize soils, but they require regular mowing and periodic fertilizing to maintain plant vigor. These species are also invasive and can out-compete native plant species. These non-native species generally provide little food or cover for birds or other wildlife. The use of these species essentially wastes land that could be productive for wildlife. This is especially critical when numerous studies document the loss of native species critical to our nation's biodiversity and the health of our native ecosystems.

ALTERNATIVES

There are alternative strategies that produce vegetative cover that can stabilize the soil and provide erosion control, sequester more carbon, provide habitat for a wide range of birds and other wildlife, and have lower maintenance costs than what is currently used.

Native vegetation provides extremely valuable habitat for all varieties of wildlife, from pollinating insects to birds and mammals. Native warm season grasses used to create meadows, for example, provide extremely valuable habitat for ground-nesting birds and many mammals. Native vegetation which is naturally adapted to site-specific conditions makes for long lasting, stress tolerant, low maintenance plants. When compared with a mowed lawn, a native planting with a plant layer from one to four feet tall is actually less attractive to woodchucks and other animals whose burrows may negatively impact the performance of a cap. Once the planting is established, the burrows of these animals are typically limited to the perimeter of the cap.

Alternatives to monoculture turf grass "habitats" may include grasslands, mixed meadows, scrub/shrub habitats, and woodlands. While the selection of alternatives depends on site conditions and the desired future use of the site, appropriate selection will result in lower costs and the provision of more ecosystem services.

No opportunity to create or replace habitat should be considered too small or too isolated. Even areas of less than an acre dotting the landscape provide habitat islands for highly mobile species such as butterflies, birds, and bats, as well as their food sources.

Grasslands and Meadows

A diverse grassland community provides habitat for several species of grassland birds with declining populations. Breeding bird surveys note continuing declines in populations of many grassland birds (e.g., field sparrows, grasshopper sparrows, and Henslow's sparrow). Planting a seed mix with a both native warm and cool season grasses can provide necessary habitat and achieve all of the objectives that have already been described. Cool season grasses grow and

flower in the early and cooler part of the summer. Warm season grasses grow in the later and warmer part of the summer. Warm season grasses are better adapted to poor soils and drier conditions, making them well suited for landfill and other caps systems, as well as most formerly contaminated waste sites. The bunch-type habit of these grasses provides space for the inclusion of native forbs, wildflowers, and legumes to further improve habitat quality.

The root biomass of native warm season grasses far exceeds that of the introduced cool season grasses. This characteristic provides increased organic matter critical to soil fertility and carbon sequestration. According to an Ohio State University Fact Sheet, "Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately reemitted. This transfer or "sequestering" of carbon helps off-set emissions from fossil fuel combustion and other carbon-emitting activities while enhancing soil quality... Soil carbon sequestration can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, and enhance soil fauna activity."

While grassland and meadow communities do require some mowing/haying to prevent woody species invasion (if desired) and to maintain plant vigor, these grasses can often be managed on a three year mowing rotation. Conversely, species typically planted (e.g., Kentucky 31 fescue) require mowing and fertilization at least twice a year. In many cases in the Mid Atlantic, former waste sites may be mowed as often every three to four weeks during the growing season, depending on weather conditions. Thus the long-term mowing costs of these non-native species, as proposed for many cap systems, may be well over ten times the cost of mowing a native warm season grass community. Using 2003 estimates, it costs $50/acre to mow a Resource Conservation and Recovery Act (RCRA) cap. Using Kentucky 31 as a cap seed mixture on a 30 acre landfill and mowing monthly from May through September for six years costs $45,000. However, managing the same site planted in native grasses for six years costs $3,000. A significant savings can be realized when considering the lifetime maintenance of a landfill cover system. Several states are migrating to the use of native grasses. For example, the state of Delaware Department of Transportation (DOT) is using native species to reduce road side mowing costs.

Establishing a native grass / meadow community does take more effort, planning, and care initially. Seeding must be done at appropriate times, and sometimes requires specialized equipment. It also takes two years to fully establish the warm season grass plants. But the long-term maintenance costs will pay off, and the difference in habitat value for wildlife species and other ecological services is substantial.

Site Preparation

Final cover material should be tested for routine agronomic parameters to ensure it provides a suitable growing matrix. Native grasses are very adaptable, but grow particularly well on moderately well drained soils or better. Soil pH should be adjusted to achieve a pH of 5.5 or higher. Bring fertility up to medium levels for phosphorus and potassium, but **do not** apply nitrogen at or before planting time. Nitrogen will only stimulate weed competition. As soil used

for final cover on waste sites is often imported from other areas, it may contain levels of contaminants that are harmful to ecological receptors or be devoid of organic carbon and a natural microbial community. Project managers should consult with the BTAG to determine if soil amendments are necessary to reduce contaminant bioavailability, increase organic matter, or modify the seed mixture.

Seed Mix

The following seed mix is an example of what can be used for restoration. These species are available from commercial vendors, but orders should allow sufficient time for delivery. The seed mix and seeding rates can and should be adjusted to site specific and seasonal conditions; however these species are adapted to a wide variety of site conditions. At former waste sites where low levels of contaminants remain in the soil, species must be selected based on their tolerance of the chemical contamination in the soils.

All seeding rates are per acre of pure live seed (PLS). The PLS should be specified when ordering.

Native Grassland Species	Pounds/acre PLS
Big Bluestem (*Andropogon gerardi*)	4
Little Bluestem (*Schizachyrium scoparium*)	6
Switchgrass (*Panicum virgatum*)	2
Indiangrass (*Sorghastrum nutans*)	6
Canada Wild Rye (*Elymus canadensis*)	10
Partridge Pea *(Chamaecrista fasciculata)*	2

Cover Crop Options	Pounds/acre
Annual Ryegrass (*Lolium multiflorum*)	25
Oats (*Avena sativa*) – February through August	25
Winter Rye (*Secale cereale*) – August through January	25

The heavier seeding with the cover crop provides immediate erosion control, as it will sprout and easily become established. In the spring the cover crop and the Canadian wild rye will also act as a nursery crop to protect the smaller seedlings of the other species until they can become established. Alternatively, oat (spring through summer planting) or winter rye (fall through winter planting) seeds should be added to the mix at 25 pounds per acre. Planting of a legume species (partridge pea) will improve soil conditioning and habitat quality. When the nurse crop dies after one year, the other warm season grass species should be fairly well established, and will provide the longer term erosion control needed on landfill caps or other cap systems. Wildflowers can also be planted with the mix to provide nectar source for birds, butterflies and other insects. The following wildflower species are widely distributed and adapted to similar conditions and should be added where additional plant diversity, wildlife value, and color is desired. All of the species listed are tall enough that they will be able to compete with native grasses for sunlight.

Wildflower Species	Pounds/acre
Black-eyed Susan (*Rudbeckia hirta*)	½
Lanceleaf Coreopsis (*Coreopsis lanceolata*)	½
Common Milkweed (*Asclepias syriaca*)	½
Wild Bergamot (*Monarda fistulosa*)	½
Ox Eye Sunflower (*Heliopsis helianthoides*)	¾

There are several commercial suppliers of native seed mixes suitable for use in Region 3. These suppliers offer mixes blended for specific habitats and wildlife management needs.

Application of Seed

Spring seeding must take place by the typical regional date of last frost (for example, May 15 in southeastern Pennsylvania). Fall seeding must be delayed until soil temperatures are below 55 degrees and the seeding rate must be increased by at least 25% to account for seed loss due to herbivory and mortality. At these fall temperatures some cool season grasses will sprout immediately, however, the warm season grasses will not sprout until the next spring. The nurse crop of oat or winter rye will germinate and provide the necessary cover and erosion control. Planting, regardless of the season, should not be done during periods of severe drought, high winds, excessive moisture, frozen grounds, or other conditions that preclude satisfactory results.

Seeds of native grasses and wildflowers typically require shallow planting for good germination. Shallow planting of the seed mix can be achieved by two approaches: 1) using a grass seed drill (e.g. Tyedrill or Brillion drill seeder), set at ¼ inch depth or 2) broadcasting the seed and then spraying a ¼ to ½ inch layer of moist compost on top.

If the soil is known or suspected to contain large numbers of weeds seeds or roots, then the weeds should be allowed to sprout and be treated with herbicide prior to seeding with a native seed mix.

If steep slopes are seeded, a biodegradable erosion control blanket (e.g., jute) should be staked over the seeded area to reduce soil and seed erosion.

Monitoring and Maintenance of Grasslands / Meadows

Monitoring the seed germination and controlling weeds in the first growing season is critical to success of the grass/forb planting (Ernst 2010). Monitoring must begin once soil temperatures reach 60 degrees. Grasses, forbs, and weed seedlings must be identified.

During the first full growing season the cool season grasses (e.g., Canada Wild Rye) will be the first plants to sprout. The warm season grasses (e.g., Bluestems, Switchgrass, and Indiangrass) take longer to sprout, and will primarily establish roots during this season.

Throughout the first growing season, mowing should be used to reduce the competition from weeds and prevent weeds from dropping seeds. Seeded areas must be mowed including any strips of grass between trees and shrubs. Each time the weeds reach 12 inches tall or form flowers, the area will be mowed to 7 inches high using a sickle bar or brush hog (Ernst 2010). A lawn mower is not acceptable for this task unless the blade can be set above 7 inches. Mowing will generally be required two, perhaps three times, depending on rainfall, to reduce annual weed invasion and enable light to reach some of the small warm season grass seedlings. Mowing should be timed to prevent seed production by annual weeds (Ernst 2010).

Monitoring will resume in the early spring of the second growing season. Grass areas should be mowed in early spring with the blade height at 10 inches above the ground to avoid damaging the crowns of the plants. In late spring, the grasses, forbs, and weeds will be identified. The area will be mowed again only if weeds are growing to 18 inches or blooming. Mow no lower than 10 inches, as mowing lower will significantly damage the crown of these grasses, cause mortality, or open site for invasion by less desirable species.

During the third and subsequent growing seasons, mow one-third of the site once a year in early spring (before April 1), and rotate so that each area of the site is mowed approximately once every three years. Alternatively, half the site can be mowed each year. These cycles may be adjusted to meet local concerns or needs, but mowing should occur no more frequently than once per year, and ideally rotating portions of the site will not be mowed annually. After mowing, the area should by "hayed" (i.e., collect debris) because the warm season grasses are very dense and mowed debris will kill new growth trying to germinate. Mowing should not be done during the nesting season (April 15 through July 30) to preclude killing ground-nesting birds and their eggs/young. Mow no lower than 10 inches, as mowing lower will significantly damage the crown of these grasses, cause mortality, or open site for invasion by less desirable species. As an alternative to mowing, controlled burning may be used to manage grassland and meadows. Controlled burns replicate the natural processes of these fire-dependent communities and return nutrients back to the soil. Controlled burns should also be performed prior to nesting by birds (before April 1).

It is important to note that warm season grass species take several years to become established and substantial top growth may not occur until the third year. As long as weed species are mowed as specified to provide sunlight to the small seedlings, these grass species are relatively easy to establish.

Additional Monitoring and Maintenance Concerns

During the establishment period, the site should be managed for the control and elimination of non-native invasive plant species (e.g., fescue, Johnson grass, Japanese honeysuckle, Chinese lespedeza) from within and from the perimeter of the planting. Techniques employed for control of undesirable plant species can consist of physical removal and the spot or wick application of herbicides. Control of these invasive species should only be necessary during the establishment period.

During the establishment period, the site should be monitored for any significant erosion. Areas exhibiting erosion should be restored to pre-disturbance conditions as soon as possible and stabilized with standard erosion controls methodologies including, but not limited to: biodegradable matting, seeding with a native seed mix that includes a cover crop, and depending on severity of erosion, silt fencing, or staked hay bales to reduce soil runoff. Jute matting is preferred as it is 100% biodegradable and is less harmful to wildlife.

Performance Standards

A metric that can be used to monitor the success of a warm season grass planting is the number of healthy seedlings of the target species. In late summer of the seeding year, the minimum acceptable standard is an average of at least 2-4 vigorous seedlings per square foot. By mid summer of the second year, an average of 2 vigorous seedlings per square foot should be present. Utilizing these metrics in the first two years, suitable total areal target coverage should be achievable by mid summer of the fourth year. At this point the vegetative cover at two feet above the ground should be 85%. Monitoring and maintenance of the grasses and forbs may be discontinued when the seeded plants provide 80 % soil cover and weeds occur at less than 10%.

Scrub/Shrub and Woodland Habitats

Trees and shrubs can be planted after seeding of grasses and forbs has been completed. Deciduous trees and shrubs may be planted from mid October through mid May (mid April in Virginia) whenever soil conditions permit. Most conifers should only be planted in the spring. If seeding has been done in the late spring or later, then planting of woody plants must be delayed until fall. Bareroot plants can be installed with a tree planter or by hand, whereas potted plants must be planted by hand. Trees and shrubs are generally planted in staggered rows with row and plant spacing determined by the species being planted. Generally species are randomly mixed within each row. Tree and shrub selections must be made according to habitat desired and site specific conditions, including, as necessary, their tolerance of the chemical contamination in the soils. Project managers should consult with the BTAG to determine the appropriate species for the conditions and objectives at each site.

Monitoring and Maintenance Requirements and Performance Standards

Monitoring of the woody plants must be performed annually in spring and fall. Evidence that each species of trees/shrub is growing is provided by monitoring 10% of the plants (e.g., height, spread). Each plant will be examined for evidence of browse or insect damage, bark stripping, or disease. If damage is present on greater than 40% of the plants, a control program should be implemented (e.g., routine spraying, installing tubes). Dead or moribund trees and shrubs will be replaced in October. Herbaceous vegetation should be mowed between the rows of trees and shrubs annually until the plants get tall enough to compete. Monitoring and replacement of woody plants must be conducted to achieve 80% tree survival and 80% shrub survival of at least half the species planted.

ROOTS

The greatest hesitancy surrounding the use of any vegetation other than turf grasses for site restoration is associated with the misunderstanding of root systems of the alternative species. Excavation of plants and examination of root structures indicates that most roots:

- are within the top 18" of soil;
- follow water, won't go through impervious material in search of water;
- follow the path of least resistance; even grow horizontally over an impervious layer;
- take advantage of cracks in clay caps that are most likely attributable to desiccation'
- will "drain" any water that flows into the voids in the cap

(Robinson and Handel 1995, Handel et al. 1997, Mooney et al. 2007),

REGION 3 EXAMPLES

Delaware

- Tybouts Corner, Wilmington
- Wildcat Landfill, Dover

Maryland

- NAS Patuxent River, MD (Site 11 Former and Current Sanitary Landfills, Sites 1 Fishing Point LF and Site 12, Landfill Behind the Rifle Range)
- Southern Maryland Wood Treating, Hollywood
- Woodlawn County Landfill (LF), Cecil County, Woodlawn

Pennsylvania

- Berks County Landfill, Sinking Springs
- BoRit Asbestos, Ambler
- Butz Landfill, Monroe County Township
- Craig Farm Drum Dump, Armstrong County
- Dorney Road Landfill, Mertztown
- Eastern Diversified Metals, Schuylkill County Rush Township
- Hamburg Lead Site, Hamburg
- Industrial Lane Landfill, Northhampton County
- Metal Bank, Philadelphia
- MW Manufacturing, Valley Township, Montour County
- Navy Ship Parts Control Center, Mechanicsburg
- Revere Chemical Co., Nockamixon Township
- W.R.G. 4 Vermiculite Site, Ellwood City

Virginia

- Avtex Fibers, Warren County, Front Royal

- Norfolk Naval Shipyard, Portsmouth
- USN St. Juliens Cr. Annex, Chesapeake

West Virginia

- West Virginia Ordnance, Pt. Pleasant

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